Agricultural Economic Report No. 178

Economic Consequences of Restricting the Use of Organochlorine Insecticides on

COTTON
CORN
PEANUTS
and TOBACCO

U.S. DEPARTMENT OF AGRICULTURE Economic Research Service

PREFACE

This report presents estimates of the economic consequences of restricting the use of organochlorine insecticides on selected crops in the United States. Farmers are the primary focus. But the effects of such action would extend to the pesticide industry, consumers, and the total environment.

Restriction is viewed as a means of reducing, not banning, the use of organochlorines by farmers. It includes the substitution of other insecticides to the maximum that would still provide effective control with known technology and maintain production at reasonable costs. The estimates assume no substantial changes in insect infestations.

Data on farm use of insecticides for 1966, the most recent available, are the foundation for the analysis. All quantities of insecticides are expressed in pounds of active chemical ingredients. The terms organochlorines, organophosphorus compounds, and carbamates refer to insecticides only.

Special acknowledgment is made to the following personnel of the Agricultural Research Service for their technical advice in the preparation of the report: Leo G. K. Iverson, Assistant Deputy Administrator, Regulatory and Control; Kenneth C. Walker, Assistant to the Deputy Administrator, Farm Research; and Clarence H. Hoffmann, Associate Director, Entomology Research Division, Farm Research. The authors are indebted to staff members of the Entomology Research Division for their evaluation of the individual crop sections. Also, Fred T. Cooke, Jr., and John H. Berry, fieldmen of the Farm Production Economics Division, contributed information for the cotton and corn sections.

It is the policy of the U.S. Department of Agriculture to continually review needs for insecticides and to use and recommend only the necessary, efficacious, less persistent ones that are least hazardous to people, property, and the quality of the environment, whether they are organochlorine, organophosphorus, carbamate, or other chemical compounds. It is also recognized that organochlorines vary widely in their persistence, some of them being less persistent than alternative organophosphorus and carbamate insecticides.

Use of trade names in this report is for identification only and does not constitute endorsement of these products or imply discrimination against other similar products.

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Washington, D. C. 20250 March 1970

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The value of organochlorine insecticides in the production of cotton, corn, peanuts, and tobacco is beyond question. They provide the only effective control for a few insects at the present time. However, usage of most of these insecticides could be selectively restricted over a period of 2 to 3 years with only modest increases in costs to farmers.

More than three-fourths of the 72 million pounds of organochlorines used by farmers on the four crops in 1966 could have been replaced by other insecticides without affecting production. However, costs for insect control on these crops would have increased $2.23 an acre treated, a total of nearly $27 million. This was about 0.3 percent of their 1966 farm value.

Forty-two million pounds of organophosphorus and carbamate insecticides would have been required to replace approximately 55 million pounds of organochlorines, mainly toxaphene, DDT, and aldrin, used on the four crops in 1966. The principal chemicals that would have been substituted were methyl parathion, diazinon, and carbaryl. For effective insect control on cotton and corn, 17 million pounds of organochlorines would still have been needed. On cotton, some of the substitute chemicals would have required supplementation, while on corn the organochlorines were the only effective insecticides for certain insects. Estimates of additional costs and quantities of insecticides which would have been replaced, still needed, or substituted in 1966 are shown below for individual crops:

Selective restriction of organochlorines, by crops, 1966

Crop	Farm value	Additional costs		Quantity of:		
		Total	Per acre treated	Organochlorines replaced	Organochlorines still needed	Substitutes used 1/
	Million dollars		Dollars	Million pounds		
Cotton	1,258	15.4	3.12	43.1	6.6	29.5
Corn	5,106	7.3	1.23	5.4	10.8	6.3
Peanuts	272	1.4	2.90	3.3	---	2.0
Tobacco	1,253	2.6	4.22	3.1	---	4.1
All crops	7,889	26.7	2.23	54.9	17.4	41.9

1/ Organophosphorus and carbamate insecticides.

Costs of replacing the organochlorines on cotton, corn, peanuts, and tobacco in 1966 represent the maximum for the foreseeable future. Since 1966, the trend toward substitution of organophosphorus and carbamate insecticides for organochlorines has continued for the four crops, but at different rates. Reduction in the use of organochlorines has been caused primarily by wider spread insect resistance and the availability of new, more effective chemicals. (In 1966, the U.S. Department of Agriculture discontinued recommendations for some of the organochlorines on these crops.) Acreages of corn, peanuts, and tobacco declined from 1966 to 1969, but cotton plantings increased. After examining the trends in insecticide usage and changes in acreages for the four crops, it was estimated that the cost of restricting organochlorines in 1969 would have been about 18 percent less than in 1966--$22 million, compared with $27 million. The reductions in additional costs from 1966 to 1969 were $2.5 million for corn, $0.9 million each for both peanuts and tobacco, and $0.6 million for cotton.

The consequences of restricting organochlorines extend to the pesticide industry, consumers, and the environment. In 1966, some pesticide manufacturers would have gained, others would have lost, but total industry dollar sales of insecticides would have increased. Most of the increased costs of insecticides would probably have been absorbed by farmers. In the long run, somewhat higher food and fiber prices must be weighed against the possibility of lower residue food and a healthier environment.

The broad spectrum insecticidal properties of the organochlorines, combined with long residual life and relative safety in handling, make them desirable for many control purposes. But their residues which remain active in the soil and water are hazardous to certain species of fish and wildlife. The organochlorines also tend to accumulate in the fatty tissues of warmblooded animals, including man. Though not persistent, many of the organophosphorus and carbamate insecticides are much less safe for those who handle and apply them, and their detrimental effects tend to be acute rather than chronic. They also have a greater tendency to suppress insect parasites and predators and thus even more insecticides could be required.

The study reveals the following additional information on production and farm use of organochlorines, phosphorus, and carbamate insecticides:

(1) Domestic use of organochlorines declined about one-sixth from 1958-59 to 1966-67. All of the decline was in DDT, with domestic use cut in half during the 8 years.

(2) Farmers buy about 70 percent of all organochlorines used domestically. In 1966, 93 percent of farm use was for crops, 5 percent for livestock, and 2 percent for other purposes. Cotton, corn, peanuts, and tobacco accounted for 87 percent of the crop use of organochlorines.

(3) Concentration of use of organochlorines varied greatly. In 1966, 5 million acres of cotton received an average application of 10 pounds of organochlorines an acre. In contrast, 1 pound an acre was applied to 15 million acres of corn. Rates for peanuts and tobacco were about midrange.

(4) Of the primary substitutes, organophosphorus and carbamate insecticides, production is reported only for methyl parathion and parathion. Farm use accounted for only 30 percent in 1966. Most of the remaining production was exported.

(5) Organophosphorus and carbamate insecticides increased from 33 to 36 percent of the farm use of synthetic organics from 1964 to 1966. Carbaryl, methyl parathion, and parathion were the leading compounds and accounted for 19 percent of farm use of synthetic organics in 1966.

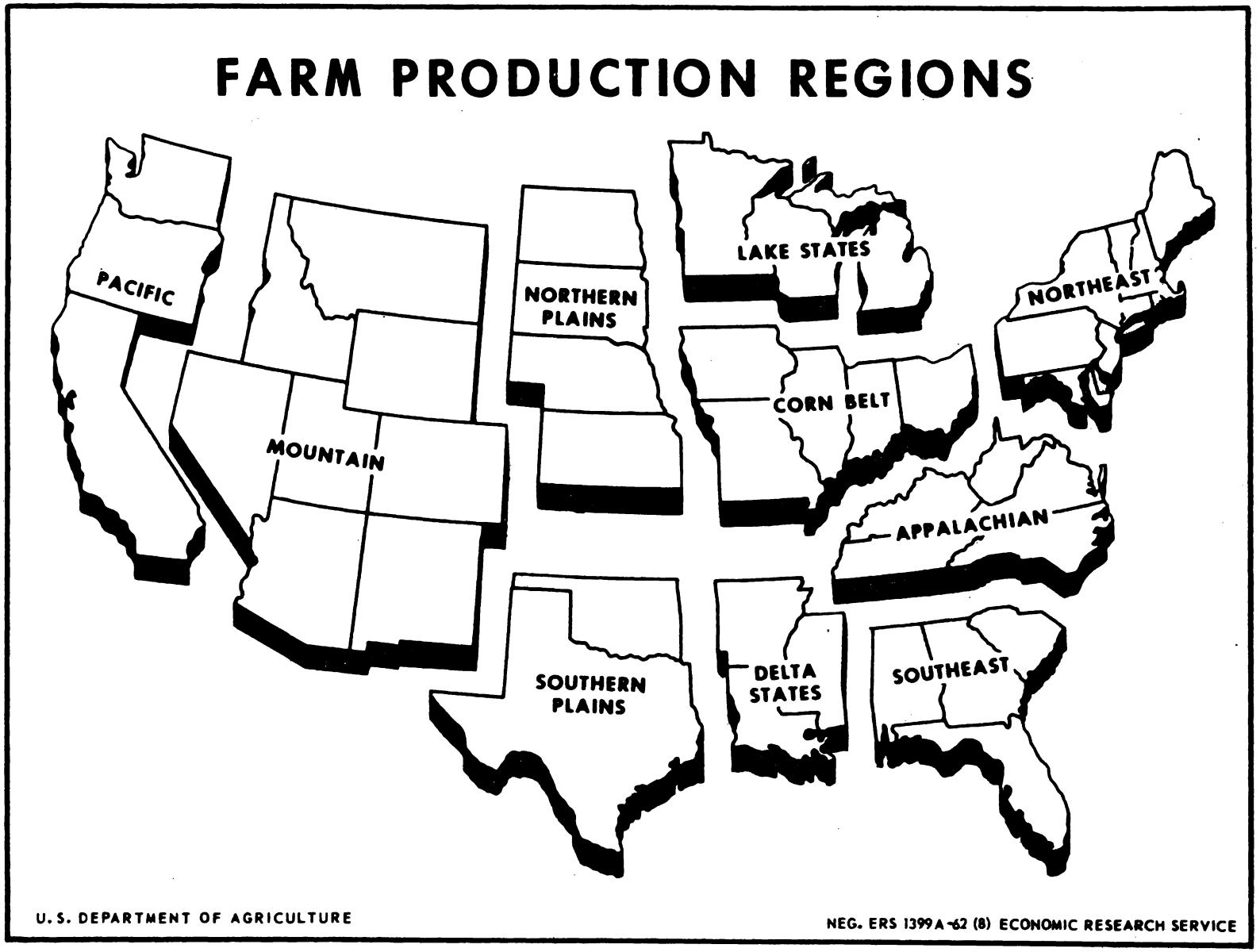
FARM PRODUCTION REGIONS
PACIFIC
MOUNTAIN
NORTHERN PLAINS
LAKE STATES
CORN BELT
NORTHEAST
APPALACHIAN
SOUTHERN PLAINS
DELTA STATES
SOUTHEAST
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Figure 1

ECONOMIC CONSEQUENCES OF RESTRICTING THE USE OF ORGANOCHLORINE INSECTICIDES ON COTTON, CORN, PEANUTS, AND TOBACCO

by

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INTRODUCTION

Insecticides have assumed an increasingly important role in the production of food and fiber in the United States. Increased specialization and more intensive farming have been made possible in part by use of insecticides. Modern farm practices have increased crop production, but they have also enhanced the favorable environment for insects. Insect populations have increased so that even more insecticides are needed.

The growing significance of insecticides reflects favorable cost-benefit ratios for individual farmers. The effects of insecticides, however, go far beyond the farm boundary. Some are persistent and remain in air, water, soil, and food. This results in a spillover effect on persons who have had no choice in their use. Thus, conflicting objectives exist, and choices and decisions are required that range from those affecting individual farmers to those that concern total society.

There is a continuing concern about the relative benefits and hazards of organochlorine insecticides--primarily aldrin, DDT, and dieldrin, and to a lesser extent benzene hexachloride, heptachlor, lindane, Strobane, TDE, and toxaphene. A comprehensive evaluation is needed to place this problem more clearly in perspective. The need encompasses technical, economic, social, and political questions. However, the main focus of this report is the aggregate economic effect on U.S. farmers of restricting the use of organochlorine insecticides on selected crops.

First, an overview is presented of some of the effects on the pesticide industry, farmers, consumers, and the environment of restricting the use of organochlorine insecticides. This is followed by a summary of trends in production of organochlorines and the extent of their use in farming. Possible alternatives are identified and the extent that shifts to such alternatives have already occurred is discussed. The report concludes with an estimate of the economic effect on U.S. farmers of restricting the use of organochlorines on cotton, corn, peanuts, and tobacco for 1966, with an indication of change to 1969. These four crops accounted for 87 percent of the crop use of organochlorines in 1966.

IN PERSPECTIVE

The overall effect of restricting the farm use of organochlorine insecticides poses a number of technical, economic, social, and environmental questions. A brief consideration of some of these matters and their consequences to the pesticide industry, farmers, consumers, and the environment is appropriate.

With few exceptions, insects can be technically controlled in a number of ways. However, the most feasible substitutes for organochlorines at the present time are the organophosphorus and carbamate insecticides.

Pesticide Industry

In general, organophosphorus and carbamate insecticides which substitute for the organochlorines are higher priced--an important reason why they have not been used more extensively. However, their use is increasing primarily because the organochlorines no longer provide effective control for some insects.

In time, cheaper and more effective nonpersistent chemicals may be developed which will tend to reduce the cost differential which now exists. However, an examination of the structure of the pesticide industry and the proprietary and differentiated nature of its products suggests higher, not lower, cost alternative insecticides in the immediate future.

Some insight into the consequences to the pesticide industry can be gained by considering the number of companies which would have been affected in 1966 if sales of DDT, toxaphene, and aldrin had been reduced and sales of methyl parathion, diazinon, and carbaryl increased. These were the principal organochlorines used by farmers in 1966 and the chemicals that would most likely have been substituted for them in substantial quantities.

Seven companies producing organochlorines would have lost sales; six companies making substitute materials would have gained; and one company would have lost on one product but gained on another. Losers included five companies making DDT and two making toxaphene. Gainers included four manufacturers of methyl parathion and two proprietary producers of diazinon and carbaryl. The company losing sales from aldrin would have gained sales from methyl parathion. The shift in chemicals would not have improved prospects for lower prices resulting from increased competition.

One important characteristic of the pesticide industry is the expense of developing products. Research costs are high. One estimate is that only one in 1,800 new compounds reaches the retail market. The time lapse between the first experimentation and a marketable product is said to average 2 to 5 years. Such high costs usually confine research, discovery, development, and production to firms with large financial resources. The whole process of development of proprietary and differentiated products tends to limit price competition. Even those chemicals which are no longer proprietary are manufactured by a small number of large companies.

The pesticide market is a small share of the total chemical business of most pesticide producers, and the outlets for insecticides are often limited and specialized. The loss of the market for organochlorines might discourage manufacturers from developing and producing insecticides, especially with the prospect of continued close surveillance of pesticide usage. Also, the requirements for registering new products are likely to increase. Such factors could further reduce competition in the pesticide industry.

From the standpoint of both farmers and the pesticide industry, gradual application of restrictions on the use of insecticides is desirable. If restrictions are imposed rapidly, prices of organochlorines and their substitutes may change precipitously in opposite directions. To meet demand, manufacturers of the substitute products will need time to increase their production capacity. Similarly, manufacturers of organochlorines will have to phase out their production facilities gradually to minimize losses.

While this is only a cursory look at the impact on the pesticide industry of restricting the use of organochlorines, the short-term prospects are for less price competition and higher costs to farmers. The sales and profits of some companies would clearly increase while others would decline. For the industry, sales and profits would rise.

Farmers

Restrictions on the use of organochlorines would increase production costs to farmers. The substitute chemicals generally cost more per pound, and additional applications are needed for some crops for effective insect control. Even though total quantities of the substitute materials might be less, total costs would be higher. Increases in farmers' costs would vary greatly by type and size of farm and by geographic area; but in the aggregate, the increase would not be large. For most farm products, insecticides represent a relatively small part of total inputs. For all farm production in 1966, insecticides were equivalent to less than 4 percent of farm expenditures for fuel, machinery, and fertilizer.

In the short run, higher costs of insecticides would not affect supply or prices of most farm products. Over time, higher insecticide costs along with increasing costs of other inputs, particularly labor, machinery, and land, would exert pressure on the marginal farmer and influence the current trend toward increasing size of farms. The effect of increases in insecticide costs on future supply and prices of farm products is likely to be slight.

Consumers

Consumers are interested in an ample supply of high-quality food and fiber at reasonable prices. The interaction of supply and demand determines consumer prices. Demand tends to increase with population growth. Market supply in the short run can fluctuate widely, but is little influenced by modest changes in grower costs. Thus, in the short run, product prices would not be affected by selective restriction of the use of organochlorines; rather, increased insecticide costs would be absorbed by farmers.

In the long run, it might seem possible that increased input costs, i.e., more expensive insecticides, could reduce the supply of farm products and increase prices. But, for most farm products, insecticides represent a small part of total inputs. Thus, restricting the use of organochlorines would not likely have a perceptible effect on supply and consequently on consumer prices. However, a ban on the use of organochlorines without effective alternatives could reduce the supply of farm products and increase consumer prices.

A nonprice effect on consumers would be the change in quantities and types of chemical residues ingested through food. Although the long-term effects of restricting the use of organochlorines cannot be estimated on the basis of existing data, it is presumed that consumers would consider themselves benefited by the shift in use of chemicals.

Thus, it would seem that the net effect on consumers is positive. On balance, slightly higher food prices must be weighed against the expectation of lower residue food and less hazard to the environment.

Environment

The question of restricting the use of organochlorine insecticides cannot be answered without some consideration of the effects of the alternative groups of chemicals on the environment. Possibly, it is sufficient to characterize the effects of the organochlorine, phosphorus, and carbamate insecticides on those who handle and apply them, on consumers of food and fiber, and on some of the elements of our natural environment.

The organochlorines are the most widely used insecticides in the United States and in the world. They are effective against a large number of pests which must be controlled to assure adequate supplies of food and fiber. Their broad spectrum insecticidal properties, combined with long residual life and relative safety in handling, make them desirable for many control purposes. However, some organochlorines have adverse characteristics. They decompose slowly under most conditions, and their residues remain active in the soil and water of our natural environment. These residues are hazardous to certain species of fish and wildlife. They have a tendency to accumulate in the fatty tissue of warmblooded animals, including man.

The organophosphorus and carbamate insecticides provide effective control of most of the insects attacking crops. But there are a few insects for which they are not effective. In contrast to the organochlorines, they degrade rather quickly and appear to pose no serious long-term residue problem. Though not persistent, they have other disadvantages. Most organophosphorus insecticides, as well as the new carbamate, carbofuran, are toxic to warmblooded animals. Thus, one of their primary disadvantages is the potential harm to those who handle or apply them. In contrast to the organochlorines, the detrimental effects of these substitutes tend to be acute rather than chronic, and they have caused numerous poisonings (some fatal) in man. Some are capable of killing wildlife coming in contact with undecomposed pesticides. Also, since their effectiveness is relatively short, more frequent applications are needed per year, especially for soil treatment during adverse weather.

The major carbamate, carbaryl, is relatively harmless to humans, but it is very toxic to bees and to insect parasites and predators. Carbaryl also affects the physiology of certain plants. For example, it reduces the set of fruit on apples if applied within 30 days after full bloom. It can be applied just before harvest without leaving overtolerance residues on the fruit, however. Thus, use of carbaryl must be restricted to particular stages in the growth of some plants.

Conclusions

There is no effective control for a few insects other than the continued use of organochlorines. However, it appears that selective restriction of the organochlorines could be made with only modest increased costs to farmers. The transition from currently used organochlorine insecticides to alternative chemicals could probably be made for most uses over a period of 2 to 3 years with a minimum of disruption to the economy and to society.

Although some chemical manufacturers would lose sales, the net effect on the industry would be to increase sales. Consumers would stand to gain because any small increase in food prices would be more than offset by the benefits of lower residue food and a healthier environment.

Based on present knowledge, if organophosphorus and carbamate insecticides are substituted for the organochlorines, long-term environmental pollution will be reduced, even though the immediate adverse effects on wildlife in the target area may increase for some uses. The incidence of poisonings of man may be expected to rise. In contrast to the organochlorines, the detrimental effects of the substitute chemicals tend to be acute rather than chronic. Greater suppression of beneficial insects could require even greater need for insecticides with correspondingly increased costs and significantly greater insect damage. Higher loss of pollinating insects could reduce production of some crops as well as cause severe losses to beekeepers. Also, there is the possibility that development of insect resistance to currently available substitute materials would make their use impractical. If other methods of control have not been developed, it might again be necessary to revert to the organochlorines.

ORGANOCHLORINE INSECTICIDES

Organochlorine insecticides have become important in control of many farm pests since their introduction during World War II. DDT was the first to be used extensively. Some of the other organochlorines used in farming include aldrin, benzene hexachloride, chlordane, dieldrin, endosulfan, endrin, heptachlor, lindane, methoxychlor, Strobane, TDE, and toxaphene.

Production and Domestic Use

Data on production and domestic use of organochlorine insecticides are available only for DDT and the "aldrin-toxaphene" group (aldrin, chlordane, dieldrin, endrin, heptachlor, Strobane, and toxaphene). However, these

insecticides account for over 90 percent of all organochlorines used in farming. Table 1 summarizes total U.S. production and domestic use of these insecticides from 1958-59 to 1966-67: 1/

(1) The combined production of DDT and the "aldrin-toxaphene" group of organochlorines fluctuated around 250 million pounds during the study period, with no apparent overall trend. However, DDT production has been falling since 1958-59, while production of the "aldrin-toxaphene" group has trended upward.

(2) Production of DDT declined from about 64 percent to 47 percent of the total production of organochlorine insecticides. Conversely, production of the "aldrin-toxaphene" group increased from 36 percent to 53 percent of the total.

(3) An increasing percentage of DDT and the "aldrin-toxaphene" group produced in the United States is used outside the country. Domestic use dropped to 52 percent.

(4) Domestic use of the two groups of insecticides combined decreased nearly one-sixth from 1958-59 to 1966-67.

(5) All of the decline in organochlorine insecticides was in DDT, domestic use of which was cut in half during the 8 years. Only about a third of the DDT production was used domestically in the 1966-67 period. Domestic use of the "aldrin-toxaphene" group increased almost one-fifth.

Farm Use

Farmers buy about 60 percent of all the DDT and almost 75 percent of all other organochlorines used in the United States. The remainder is used by industry, government (Federal, State, and local), and homeowners.

Additional data on use of organochlorines in farming are summarized in tables 1-5:

(1) About 70 percent of the total domestic use of the organochlorines is in farming. The proportion appears to be declining, as these insecticides are being replaced by other synthetic organic insecticides.

(2) Organochlorines accounted for 66 percent of the total synthetic organic insecticides used by farmers in 1964, compared with 63 percent in 1966. Much of the difference was due to a 32-percent reduction in cotton acreage in 1966.

(3) Of the farm use of organochlorines in 1966, 93 percent was for crops, about 5 percent for livestock, and 2 percent for other purposes.

(4) The organochlorines most widely used by farmers were toxaphene, DDT, and aldrin.

1/ Tables follow the text on p. 23.

(5) In 1966, 87 percent of the crop use of organochlorines was on cotton, corn, peanuts, and tobacco. These crops accounted for 36 percent of the farm value of all crops, but occupied only 22 percent of all crop acres, not including pasture. The major use of organochlorines (60 percent) was on cotton.

(6) In 1966, organochlorines accounted for 79 percent of all insecticides used on tobacco, 77 percent on cotton, 69 percent on corn, and 59 percent on peanuts.

(7) The Southeast accounted for the largest share of the organochlorines used in the United States, but substantial use occurred in all regions. States in each production region are shown in figure 1.

(8) The intensity and distribution of the use of organochlorines varied greatly from crop to crop. In 1966, for example, an average of 10 pounds of organochlorines an acre was applied on 5 million acres of cotton. In contrast, 1 pound of organochlorines an acre was applied on 15 million acres of corn. Peanuts and tobacco were approximately midrange with an average use of about 6 and 5 pounds of organochlorines an acre, respectively.

ALTERNATIVES--ORGANOPHOSPHORUS AND CARBAMATE INSECTICIDES

The major alternatives for the organochlorines are also synthetic organics--the organophosphorus and carbamate insecticides. These insecticides were introduced soon after the organochlorines, and are widely used on feed and food crops and on livestock to avoid residues in or on the marketed products. They are gradually taking a larger share of the farm use of insecticides because certain key insects have developed increased resistance to the organochlorines.

Production

Production information from 1964 to 1968 is reported separately only for methyl parathion and parathion. The other organophosphorus and carbamates are either proprietary compounds, with one dominant producer, or they are produced by three or fewer companies and thus, by law, data are not published for these insecticides.

Production of both methyl parathion and parathion reached a peak of 36 million and 19 million pounds, respectively, in 1966 but declined in 1967 (table 6). Data for methyl parathion for 1968 shows an increase above the 1966 peak. Corresponding farm use from 1964 to 1966 shows a decline in methyl parathion and an increase in parathion. Farm use accounted for only 30 percent of the production of these two insecticides in 1966. Most of the production of methyl parathion and parathion not used on U.S. farms is exported.

Farm Use

A substantial number of organophosphorus insecticides are used in farm production. Those that were employed most extensively and in largest quantities

in 1966 include azinphosmethyl, Bidrin, diazinon, disulfoton, ethion, malathion, methyl parathion, parathion, and trichlorfon. Several others were used less widely, and a number have come into acceptance since 1966. Carbaryl was the principal carbamate used in 1966.

Additional data on farm use of the organophosphorus and carbamate insecticides may be derived from table 2:

(1) In 1964 and 1966, organophosphorus and carbamate insecticides accounted for 33 and 37 percent, respectively, of the farm use of synthetic organic insecticides.

(2) Carbaryl, parathion, and methyl parathion were the leading compounds, accounting for 20 percent of farm use of synthetic organic insecticides in 1966. Although still minor chemicals for farm use, malathion and diazinon increased in importance from 1964 to 1966.

(3) Carbaryl was used primarily on peanuts, cotton, and apples. Most of the parathion was used on cotton and corn, while the bulk of methyl parathion was applied to cotton. In addition, these three insecticides were used on a large number of other crops, but on smaller acreages.

(4) Organophosphorus compounds were the major synthetic insecticides used in fruit production. Among commercial citrus and apple growers, these products accounted for a half or more of insecticides used. A similar pattern was apparent for vegetables, with organophosphorus compounds representing one-third to one-half of the insecticides used in 1966.

ECONOMIC EFFECTS ON SELECTED CROPS (1) 2/

In 1966, cotton, corn, peanuts, and tobacco accounted for 87 percent of the organochlorine insecticides used on crops. Estimates of the economic effects of restricting the use of organochlorines on these four crops were derived by evaluating: (1) acreage and geographic distribution of each crop; (2) extent and geographic distribution of the farm use of insecticides; (3) costs of materials to farmers; and (4) alternative insecticides available. (Degree of insect infestation is implicit in the acreage treated and the extent of use of insecticides.) The direction of change in the use of insecticides for each crop from 1966 to 1969 was also estimated.

In the analysis, restriction was viewed as a means of reducing, not banning, the use of organochlorines by farmers. Restriction was further interpreted to mean the substitution of other insecticides to the maximum extent consistent with achieving effective control and maintaining production at reasonable costs. For corn, effective substitutes were not available for the control of certain insects. For cotton, some substitutes needed to be supplemented with organochlorines for effective control.

2/ Underscored numbers in parentheses refer to items in the Selected References. Information about materials and recommended rates were based primarily on (1), supplemented by USDA and university research and extension specialists.

Summary of Effects on Selected Crops

In 1966, 87 percent of the crop use of organochlorines was on four crops--cotton, corn, peanuts, and tobacco. Replacement of about 55 million pounds of organochlorines could have been effected with 42 million pounds of organophosphorus and carbamate insecticides at an additional cost of $2.23 an acre treated, or a total of $27 million (tables 28 and 29). This was about 0.3 percent of the 1966 farm value of the four crops. About 85 percent of the additional costs were for cotton and corn--cotton alone accounted for about 58 percent. Materials represented about three-fourths of the higher costs and additional applications the remainder.

Although large quantities of alternative insecticides were substituted, 17 million pounds of organochlorines would still have been needed to provide effective control of insects on cotton and corn. However, the organophosphorus and carbamate insecticides would have replaced 76 percent of the organochlorines used in 1966 (table 28). Among the major organochlorines, the use of DDT would have been reduced over 90 percent, toxaphene 85 percent, and aldrin 32 percent.

The most important substitute materials for the organochlorines in 1966 were methyl parathion, diazinon, and carbaryl. In accordance with 1966 recommendations, methyl parathion was the primary substitute on cotton. Diazinon and carbaryl were recommended substitutes on corn, peanuts, and tobacco. Functionally, carbaryl could have been substituted on cotton, but it was not included because of the higher costs.

On an acre-treated basis, additional costs of restricting the use of organochlorines would have ranged from a high of $4.22 on tobacco to a low of $1.23 on corn (table 29). Acre costs for cotton and peanuts were $3.12 and $2.90, respectively. In terms of crop values, increased insecticide costs would have ranged from a low of 0.2 percent for corn and tobacco to a high of 1.2 percent for cotton.

In total, the substitution of alternative chemicals in 1966 would have reduced quantities of organochlorines used by 76 percent, while the organophosphorus and carbamate insecticides required would have increased 163 percent. For the individual insecticides substituted, the volume of methyl parathion would have increased five times, while diazinon and carbaryl would have more than doubled the 1966 usage.

Cotton

Cotton, valued at $1.3 billion, was grown on 10.3 million acres in 1966. Cotton producers are the major users of insecticides. In 1966, 44 percent of all insecticides and 60 percent of the organochlorines used on crops were applied to cotton. Cotton farmers treated 5 million acres with 50 million pounds of organochlorines at an average rate of 10 pounds an acre. Of the total crop use of organochlorines in 1966, cotton's share was: toxaphene, 88 percent; DDT, 73 percent; and methyl parathion, 91 percent. Selective restriction of the use of organochlorines on cotton would have increased production costs an average of $3.12 an acre treated, a total of $15.4 million. This was 1.2 percent of the farm value of cotton lint and cottonseed in 1966. Growers in the Delta States would have had the highest additional costs, $6.8 million--an average of $3.90 an acre treated. In addition to the $15 million increase in production costs, about 4 million pounds of toxaphene and 2 million pounds of DDT would have been required to maintain production and to effect economical insect control.

* * * *

Cotton is the fifth most valuable crop in the United States, following corn, soybeans, wheat, and tobacco. In 1966, cotton lint and cottonseed, valued at $1.3 billion, were produced on 10.3 million acres. About 72 percent of the cotton acreage was concentrated in five States--Texas, Mississippi, Arkansas, California, and Alabama. Texas alone accounted for 41 percent.

Bollworms are important cotton insect pests throughout the cotton-growing areas. Most other cotton insect problems are more regionalized. For example, the boll weevil causes considerable damage in the Southeast, Delta States, and the Southern Plains but does not occur in the far West. Thrips and aphids are more troublesome in the Southeast and Delta States than in the western regions. In the West, cotton growers focus on controlling lygus bugs and the cotton leaf perforator.

The major use of insecticides in U.S. agriculture is in the production of cotton. In 1966, 44 percent of all insecticides and 60 percent of the organochlorines used on crops were applied to cotton. The following data on use of insecticides on cotton in 1964 and 1966 are from tables 7 and 8:

(1) Insecticides were used on cotton by 51 percent of the growers in 1966 who accounted for 54 percent of the cotton acreage.

(2) Total use of all insecticides on cotton declined 14 percent from 1964 to 1966, but acreage was down 32 percent, indicating more intensive use of insecticides.

(3) About three-fourths of the insecticides used on cotton were organochlorine compounds.

(4) Toxaphene, DDT, and methyl parathion are the most widely used chemicals on cotton. Of the total quantity of these three chemicals used on crops in 1966, cotton accounted for 88 percent of the toxaphene, 73 percent of the DDT, and 91 percent of the methyl parathion.

(5) The most significant change in the use of insecticides on cotton from 1964 to 1966 was a decline in the relative importance of DDT and both relative and absolute increases in the use of toxaphene. However, average application rates per acre were up for both DDT and toxaphene.

(6) About 80 percent of the cotton grown in the Southeast and Delta regions in 1966 was treated with insecticides. Farmers in these States accounted for 44 percent of the total acreage in cotton, but 79 percent of the organochlorines used on cotton.

(7) The relative importance of organochlorines was greatest in the Southeast where they accounted for 88 percent of all insecticides. Westward, the organochlorines decreased in importance. In the Southern Plains, organochlorines represented about 60 percent of all insecticides, and in California less organochlorines were used than other insecticides.

Organochlorine insecticides have been used on cotton since World War II when growers first began using DDT. However, in the early postwar years, inorganic insecticides such as calcium arsenate continued to be used, particularly in the Piedmont. Combinations of toxaphene and DDT in a 2-to-1 ratio became popular.

In the early 1960's, organochlorine insecticides were combined with organophosphorus compounds, primarily methyl parathion. Now a common practice is to use a combination of toxaphene, DDT, and methyl parathion (4-2-1) to control some of the most damaging cotton insects, such as the boll weevil and bollworm. Other organochlorine insecticides used to a lesser degree include aldrin, dieldrin, endrin, lindane, and Strobane.

Recent practices also include more intensive use of organophosphorus compounds--methyl parathion, malathion, azinphosmethyl, disulfoton, Bidrin, phorate, and trichlorfon--and carbamates, particularly carbaryl.

In general, current spraying practices and programs for control of insects in cotton production are more closely tailored to infestations. Except for some early season sprays, farmers are moving away from preventive insecticide treatments. However, use of preventive systemic insecticides against thrips, aphids, and spider mites is becoming more prevalent in some areas.

Most cotton growers concentrate on controlling the most damaging insects. However, the insecticides that are used for specific insects also control many others. For example, if methyl parathion is applied at rates that are needed to control the bollworm, most other cotton insects will also be controlled, provided they have not developed a resistance to the insecticide. To maintain yields, several additional applications are often needed for spray programs composed largely of organophosphorus compounds.

Costs

The first step in evaluating the economic effect of restricting organochlorines on cotton was to examine their use patterns and associated costs in 1966 for five different growing areas (tables 10-15). Organophosphorus insecticides were substituted for the organochlorines by areas based on insects to be controlled. The number of treatments and rates of application for the alternative insecticides were adjusted upward as needed to maintain production. Costs of alternative insecticides with additional applications were compared with costs of using the organochlorines.

Even with increased frequency of application and higher application rates, some organochlorines would have been needed in the spray programs to maintain production at 1966 levels. Technically, with high level management, effective insect control might be accomplished without the use of organochlorines. However, under average farm conditions, high level management cannot be assumed, and thus production could not have been maintained without the supplemental use of toxaphene and DDT. Thus, in all regions, organochlorines were retained in the ratio of one to six toxaphene and DDT sprays used in 1966. For example, on farms where 12 to 18 sprays were used in 1966, two to three sprays with toxaphene and DDT would have been necessary to supplement the organophosphorus and carbamate insecticides.

The total additional cost of limiting the use of organochlorines in 1966 would have been $15.4 million--$10.5 million for materials and $4.9 million for application (table 9). About $6.8 million of this amount would have been in the Delta States. Costs would also have been high in the Southeast (about $4.4 million), but low in the far West.

The additional cost of substituting other insecticides for organochlorines would have averaged $3.12 an acre treated. In California the cost was $1.50 an acre; in the Delta States, $3.90; and in Arizona and New Mexico, $7.22. In the latter two States, the high cost was due primarily to the expensive substitute materials needed to control the pink bollworm and the cotton leaf perforator.

In addition to the increase in total costs of $15 million, farmers in all cotton-growing areas would still have needed toxaphene and DDT. About 4.4 million pounds of toxaphene and 2.2 million pounds of DDT (about 16 percent of the toxaphene and 12 percent of the DDT used on cotton in 1966) would have still been required. About 43 million pounds of organochlorines would have been replaced by 30 million pounds of organophosphorus insecticides (table 15).

Corn

Corn is the most important U.S. crop, valued at close to $5 billion and grown on 66 million acres in 1966. Farmers treated 33 percent of these acres with insecticides. The quantity of insecticides used on cornland increased 50 percent from 1964 to 1966. The main organochlorines used on corn in 1966 were aldrin and heptachlor, while the most used organophosphorus

insecticides were diazinon and parathion. In the Western Corn Belt, 3/ corn rootworm resistance to aldrin has been spreading. By 1966, growers in that area had started to substitute other materials, primarily diazinon and parathion. In 1966, there were no alternatives for organochlorines for controlling wireworms and white grubs on about 16 percent of U.S. cornland, or 10.6 million acres. Thus, 10.8 million pounds of aldrin and heptachlor, two-thirds of the 1966 requirements, would still have been needed for effective insect control. The other corn insects treated with organochlorines in 1966 could have been controlled with organophosphorus compounds and carbamates. Such a shift would have increased total production costs for all corn growers nearly $7.3 million, less than 0.2 percent of the 1966 farm value of corn.

* * * *

Corn for grain and silage is the most important U.S. crop. It is valued at nearly $5 billion annually, and is grown on 1 in 5 crop acres. Although corn is produced in nearly every State, 80 percent of the corn acreage in 1966 was concentrated in eight States--Iowa, Illinois, Indiana, Ohio, Missouri, Minnesota, Wisconsin, and Nebraska.

Data below summarize the use of insecticides on corn as shown in tables 16 and 17:

(1) Only 15 percent of the corn farmers used insecticides in 1966, mostly on farms in the Corn Belt where the acreage grown per farm is large.

(2) Thirty-three percent of total cornland was treated with insecticides. But the intensity of the insect problem is shown by the fact that 48 percent of the acres in the Corn Belt were treated with insecticides, compared with only 18 percent of cornland outside these five States.

(3) Fifty percent more insecticides were used on corn in 1966 than in 1964. The use of insecticides on corn has been increasing at a rapid rate in recent years, indicating more intensive production of corn and possibly a rise in insect infestations. The increased use also reflects the recognition by the more progressive farmers that insecticides are an essential element of the mix of fertilizer, improved varieties, and other practices required to obtain top yields.

(4) The relative importance of the organochlorines, the major group of insecticides used on corn, declined from 78 percent of the total corn insecticides in 1964 to 69 percent in 1966. The organophosphorus insecticides increased in significance from 21 percent of the total in 1964 to 28 percent in 1966. Both substitution for the organochlorine insecticides and new organophosphorus treatments occurred during this period.

3/ The Western Corn Belt includes all major corn-producing States west of Indiana. In this report the term "Corn Belt" refers to Ohio, Indiana, Illinois, Iowa, and Missouri.

(5) The main organochlorine insecticide used on corn in 1966 was aldrin. Even though the total quantity of aldrin increased from 1964 to 1966, its relative importance declined from 68 to 60 percent of the total insecticides used.

(6) Diazinon and parathion were the most important organophosphorus insecticides used on corn in 1966. Their use increased substantially from 1964 to 1966, but they still constituted only 25 percent of all corn insecticides employed in 1966.

Changing cultural practices have intensified the insect problem in corn production. Formerly, corn was grown in 3- or 4-year rotations of corn, oats, and clover. Insects were not recognized as a major problem. Today, operators on farms with relatively level land fertilize heavily and grow corn continuously for several years on the same land. Continuous corn production creates breeding grounds conducive to destructive insects, especially soil pests.

The kinds of insects to be controlled and methods of control are different for corn than for other crops, such as cotton and tobacco. Most corn insecticides are applied to the soil, rather than to the foliage of the plant, and are generally used only once a season. Chief among these soil-infesting insects are wireworms, white grubs; cutworms, and several species of rootworms. Seed maggots and seed beetles are also classified as soil insects. Aboveground feeders include the European corn borer (adults of rootworms that feed on silk), corn leaf aphid, grasshoppers, and chinch bugs.

The organochlorine, aldrin, has been the main insecticide used on cornland. But in some areas in 1966, aldrin was no longer effective against rootworms, because they had become resistant to it. As an alternative, growers in the Western Corn Belt began treating cornland with the organophosphorus insecticides, primarily diazinon and parathion. However, these insecticides are not effective against wireworms and white grubs. They also lose effectiveness rapidly in rainy weather.

Costs

The question of costs of restricting the use of organochlorines on cornland is best considered by examining the alternatives for (1) soil insects and (2) foliar and surface insects.

(1) Soil insects.--For controlling wireworms and white grubs, there were no effective substitutes for the organochlorines in 1966. While aldrin and heptachlor continue to be needed for controlling these two insects, all of the aldrin and heptachlor used for other insects, primarily the corn rootworm, could have been replaced by diazinon or other organophosphorus insecticides.

Infestations of corn insects vary considerably by States, as shown by quantities of insecticides used (table 18). For example, the use of primarily aldrin and heptachlor in Indiana and Ohio indicates that these chemicals were still effective for control of corn rootworms. In contrast, resistance of the corn rootworm is shown rather clearly by the use of substantial quantities of diazinon from Illinois westward, particularly in Iowa and Nebraska. However,

the bulk of aldrin and heptachlor was used for control of wireworms and white grubs in 1966.

It was estimated that 16 percent, 10.6 million acres, of U.S. cornland was treated for wireworms and white grubs in 1966 (table 19). On these acres it is assumed that aldrin and heptachlor would continue to have been used in about the same ratio as in 1966. Thus, 9.8 million pounds of aldrin and 1.0 million pounds of heptachlor would not have been replaced (table 20). However, the use of 4.9 million pounds of aldrin and heptachlor for corn rootworms on the remaining 5.1 million acres would have been replaced by 5.1 million pounds of diazinon. This shift to diazinon would have increased the cost of soil insecticides to corn growers $6.2 million, or $1.22 an acre treated for corn rootworm.

(2) Foliar and surface insects.--Throughout the corn-producing areas, 0.5 million pounds of DDT, chlordane, dieldrin, TDE, and toxaphene were used in 1966 to control corn borers, cutworms, chinch bugs, corn flea beetles, grasshoppers, webworms, and army worms. Some 782,000 acres were treated with organochlorines for control of these pests at a cost of about $535,000 (table 20). The substitution of 1.2 million pounds of carbamates for the organochlorines used to treat foliar and surface insects would have increased costs $1.1 million in 1966, $1.36 an acre treated.

In total, for soil, surface, and foliar insects, selective restriction of organochlorine insecticides on corn would have increased production costs about $1.23 an acre treated,[4/] or $7.3 million in 1966, less than 0.2 percent of the farm value of corn. This is the cost of replacing 5.4 million pounds of organochlorines. But 10.8 million pounds of aldrin and heptachlor, two-thirds the quantity of organochlorines used in 1966, would still have been required to control wireworms and white grubs effectively.

Peanuts

Peanuts, valued around $272 million, were grown on 1.5 million acres in 1966. One million acres were treated with 3.3 million pounds of organochlorine and 2.3 million pounds of organophosphorus and carbamate insecticides. Peanut farmers applied an average of 6.5 pounds of organochlorines an acre on about 0.5 million acres. DDT, toxaphene, and carbaryl were the leading insecticides used. Replacing the organochlorines used on peanuts with carbaryl and diazinon would have increased costs $2.90 an acre treated. Total treatment costs would have increased $1.5 million, equivalent to 0.5 percent of the total farm value of peanuts. The increased costs would have affected chiefly growers in the Southeast who accounted for 96 percent of the organochlorines used on peanuts.

* * * *

4/ Based on treating 5,136,000 acres with diazinon and 782,000 acres with carbaryl, all of which were formerly treated with organochlorines.

The 1966 peanut crop, valued at approximately $272 million, was produced primarily in seven States--Virginia, North Carolina, Georgia, Florida, Alabama, Oklahoma, and Texas. Georgia accounted for one-third of the total acreage, and Texas one-fifth.

The following statistics indicate the extent of insecticide usage on peanuts in 1966 (tables 21 and 22):

(1) More than half, 59 percent, of the peanut growers applied insecticides. But they treated 70 percent of 1.5 million acres of peanuts grown in 1966.

(2) The organochlorines were applied at an average rate of 6.5 pounds an acre.

(3) The most widely used insecticides on peanuts were DDT, toxaphene, and carbaryl. Of 5.5 million pounds of insecticides applied, DDT accounted for 41 percent; toxaphene, 18 percent; and carbaryl, 34 percent.

(4) Carbaryl was the major substitute for the organochlorine insecticides, DDT and toxaphene.

(5) Most of the insecticides were applied on peanuts in the Southeast. In these States, although farmers planted 53 percent of the total U.S. crop, they accounted for 96 percent of the organochlorines and 60 percent of the organophosphorus and carbamate insecticides used on peanuts.

(6) Farmers in the Appalachian region have largely substituted organophosphorus and carbamate insecticides in their insect control programs. Of 0.9 million pounds used in the region in 1966, 53 percent were carbamates and 34 percent were organophosphorus insecticides. Although more than a fourth of the U.S. peanut acreage is in Texas and Oklahoma, only small quantities of insecticides were used in these States.

The declining use of organochlorine insecticides in peanut production is due primarily to insect resistance. Some farmers are using organophosphorus and carbamate insecticides exclusively, while others are substituting a carbamate for at least one dusting. However, farmers who do not use organochlorines usually require an additional application of insecticides to control thrips and leafhoppers.

Costs

The replacement of the organochlorines used by peanut farmers in 1966 with organophosphorus and carbamate insecticides would have increased total costs an estimated $1.5 million, $2.90 an acre treated (table 23). This was about 0.5 percent of the 1966 value of the peanut crop. The increase in costs would have been due to more applications of higher cost materials; pounds of active insecticide materials used would have declined. The increase in production costs would have been felt primarily by growers in Georgia, Alabama, and Florida who accounted for 96 percent of the organochlorines used on peanuts in 1966.

Tobacco

Tobacco, valued at $1.3 billion, was grown on about 1 million acres in 1966. Tobacco farmers used 3.9 million pounds of insecticides to treat 788,000 acres. Organochlorines comprised 79 percent of the insecticides used. Tobacco farmers applied an average of 5 pounds of organochlorines an acre on about 0.6 million acres. TDE and DDT were the most widely used organochlorines on tobacco, accounting for nearly 90 percent of the organochlorines in 1966. The important substitutes for TDE and DDT were carbaryl and parathion. Replacing the organochlorines used on tobacco would have increased costs $4.22 an acre treated, a total of $2.6 million for all tobacco producers. This was equal to about 0.2 percent of the 1966 farm value of tobacco.

* * * *

Tobacco is a high-value cash crop grown largely in the Appalachian and Southeast regions of the United States. In 1966, tobacco valued at $1,253 million was grown on about 1 million acres (table 24). Two States, North Carolina and Kentucky, had 61 percent of the acreage. North Carolina alone had 43 percent of the total.

Data shown below on use of insecticides on tobacco are from tables 24 and 25:

(1) Organochlorine insecticides are widely used in tobacco production. In 1966, organochlorines comprised 79 percent of the 3.9 million pounds of insecticides used.

(2) In 1966, about 0.6 million acres were treated with organochlorines at an average rate of 5 pounds an acre.

(3) In 1966, 3.1 million pounds of organochlorine insecticides were used, compared with 4.3 million pounds in 1964. The decline was partly due to a reduction in tobacco acreage. The use of organophosphorus and carbamate insecticides declined relatively less, indicating some substitution for the organochlorine insecticides.

(4) TDE and DDT were the main organochlorine insecticides used on tobacco, accounting for almost 90 percent of the total in 1966. TDE alone represented nearly 60 percent. Parathion and carbaryl were the leading organophosphorus and carbamate insecticides applied on tobacco.

(5) In 1966, the most intensive use of organochlorines on tobacco did not occur in the leading tobacco States. North Carolina and Kentucky with 61 percent of the total acreage in tobacco accounted for only 42 percent of the organochlorines used.

Tobacco insects must be controlled in plant beds, on newly set plants, and on established plantings. Some insects, such as flea beetles and aphids, may be a problem during all stages of production. In general, however, the more damaging insects tend to be associated with only one or two stages of tobacco production. The four most damaging tobacco insects are budworms, flea beetles, wireworms, and hornworms.

Organochlorine insecticides were introduced after World War II to control tobacco insects and have since received widespread acceptance. Earlier, inorganic insecticides, lead arsenate and Paris green, were applied extensively. The inorganic insecticides were still used in the early fifties.

Wireworms on newly set tobacco plants have been controlled with aldrin, heptachlor, chlordane, and dieldrin. However, in recent years certain species of wireworms that attack tobacco in some areas of the South have become resistant to the organochlorine insecticides. DDT, endrin, and dieldrin were often used for control of such insects as cutworms, flea beetles, and budworms. Endrin and TDE were also used for hornworms. In more recent years, the use of organochlorine insecticides on tobacco has been sharply reduced--DDT and TDE to a lesser extent than the others. The use of toxaphene was discouraged in the early 1950's because of the objectionable odor when the tobacco was smoked. DDT is not used extensively on field planting primarily because of residues and its ineffectiveness against one of the two species of hornworms that attack tobacco. DDT and TDE are still used for budworm control.

There has been a general shift to organophosphorus and carbamate insecticides by tobacco growers. Organophosphorus compounds--diazinon, azinphosmethyl, malathion, and parathion--will control most tobacco insect pests, such as aphids, flea beetles, grasshoppers, hornworms, and the tobacco suckfly. The tobacco budworm, which also does extensive damage to field plantings, can be controlled by carbaryl, endosulfan, or the biological control agent Bacillus thuringiensis.

Similarly, for plant beds and on newly set plants, carbaryl, malathion, parathion, and diazinon can be used to control most insects, including aphids, flea beetles, grasshoppers, vegetable weevils, wireworms, slugs, and grubs of the June beetle.

Costs

The cost of restricting the use of organochlorine insecticides on tobacco was determined by first computing the total expenditure on organochlorines in 1966 ($4.2 million as shown in table 26). TDE and DDT were the primary insecticides used, accounting for 82 percent of the total costs.

The cost of substituting an aggregate spray program of organophosphorus and carbamate insecticides was then estimated. The basis for this estimate was the tobacco acreage treated with organochlorines in 1966 and the average application rates for the substitute chemicals the same year. The number of applications was increased 20 percent to insure effective control. The quantities of organophosphorus and carbamate insecticides applied per acre were slightly higher than for the organochlorines, but prices per pound of material were lower (tables 26 and 27).

Thus, a shift to the organophosphorus and carbamate insecticides in production of tobacco would have increased total costs for materials an estimated $1 million (table 27). Additional applications needed would also have increased total costs by $1.6 million, for a total increase in tobacco production costs (materials and application) of $2.6 million. This was about 0.2 percent of the farm value of tobacco in 1966.

Costs of insecticides used on tobacco are relatively small, compared with the value of the crop. In 1966, insecticide materials averaged about $9.12 an acre receiving treatment. The value of the tobacco averaged $1,286 an acre. The additional costs of replacing organochlorines with other insecticides would have added $4.22 an acre to the production costs of farmers making these changes. It would affect about 0.6 million acres, 65 percent of the total tobacco acreage.

Changes in the Use of Insecticides, 1966-69

Costs of restricting the use of organochlorines on cotton, corn, peanuts, and tobacco in 1969 would have been lower than in 1966. Between 1966 and 1969, the trend in the substitution of organophosphorus and carbamate insecticides for the organochlorines continued for the four crops, but at different rates. Wider spread insect resistance and new, more effective chemicals have been major factors in the rate variation. After examining the trends in insecticide use and changes in acreages for the four crops, it was estimated that the cost of restricting the use of organochlorines in 1969 would have been about 18 percent less than in 1966--$22 million, compared with $27 million for corn, $0.9 million each for peanuts and tobacco, and $0.6 million for cotton.

--$2.5 million less

Cotton

Additional costs of restricting the use of organochlorines on cotton in 1969 would have been down to $14.8 million, only 4 percent under the $15.4 million estimated for 1966. The lower costs would have resulted mainly from changes in spraying practices by cotton growers in the Southern Plains States of Texas and Oklahoma. Between 1966 and 1969, primarily because of insect resistance to DDT, cotton growers in these two States largely shifted to the organophosphorus and carbamate insecticides to obtain more effective insect control. About two-thirds of the additional costs in 1966 in the two States, or $1.8 million, would not have been applicable in 1969. The lower additional costs for these growers would more than offset the $1.2 million higher costs resulting from an 8-percent increase in cotton acreage in all areas from 1966 to 1969.

Corn

In 1969, additional costs of restricting the use of organochlorines would have been less than in 1966 to the extent that resistant corn rootworms had spread to more areas. Corn growers affected would have already shifted from organochlorines to other materials, and thus, would have incurred these additional costs prior to 1969.

Current reports indicate that the resistant species of corn rootworm had not spread into Ohio and Indiana in 1969 but had become more widespread in the Western Corn Belt. Since 1966, an estimated 2 million additional acres could have become infested with corn rootworms resistant to the organochlorines. This cornland would have been treated with organophosphorus insecticides in 1969. Thus, costs of restricting the organochlorines on corn would have declined about $2.5 million from 1966. It was assumed that the increase in areas infested with corn rootworms was the only significant change from 1966 to 1969. Although acreage of corn declined 5 percent from 1966 to 1969, the decrease was offset by the continuing trend of increasing the percentage of cornland treated with insecticides.

Some of the new organophosphorus and carbamate insecticides being tested are believed to provide adequate control of all soil insects infesting corn. If they fulfill expectations, the need for organochlorines on corn would be reduced markedly. Some of these new materials now being used in limited quantities include phorate, Dyfonate, Dasanit, carbofuran, trichlorfon, Bux, and disulfoton. Per acre cost of treatment with these new materials is expected to be significantly above that of the organochlorines.

Peanuts

Peanut producers use carbaryl, diazinon, and systemic insecticides primarily. These and other currently available organophosphorus and carbamate insecticides are adequate for most insect control on peanuts for the foreseeable future. In 1966, the USDA withdrew recommendations for using organochlorines on peanuts, except to control the white-fringed beetle. But less than 1,000 acres of peanuts usually require treatment for this pest. With the increasing spread of resistant insects and reduced effectiveness of the organochlorines, use of these insecticides on peanuts in 1969 was probably down two-thirds from 1966. Thus, the estimated cost of restricting the use of organochlorines for peanut farmers would have been $0.5 million in 1969, compared with $1.4 million for 1966.

Tobacco

More azinphosmethyl and carbaryl are being substituted for DDT and TDE in the control of tobacco insects. Diazinon has been substituted for some of the aldrin, dieldrin, and endrin in tobacco insect control programs. The reduced use of organochlorines is consistent with recent recommendations. Thus, costs of restricting the use of organochlorines for tobacco farmers would have been less in 1969 than in 1966. Estimated additional costs for tobacco would have been down about one-third from $2.6 million to $1.7 million. Although tobacco producers are using more of the substitute materials, the transition has been slower than for peanuts.

TABLES

Table 1.--Production and domestic use of DDT and the "aldrin-toxaphene" group of organochlorine insecticides, United States, 1958-66

Year beginning Oct.	Production			Domestic use		
	DDT	"Aldrin-toxaphene" group 1/	Total	DDT	"Aldrin-toxaphene" group	Total
	Million pounds					
1958	156	91	247	79	73	152
1959	160	89	249	70	76	146
1960	176	105	281	64	78	142
1961	163	104	267	67	82	149
1962	188	101	289	61	79	140
1963	136	100	236	51	83	134
1964	131	113	244	53	81	134
1965	141	125	266	46	87	133
1966	114	129	243	40	86	126

1/ Includes aldrin, chlordane, dieldrin, endrin, heptachlor, Strobane, and toxaphene.

Source: (18).

Table 2.--Crops and livestock: Quantity and percentage of organochlorine and other synthetic organic insecticides used, United States, 1964 and 1966 1/

Synthetic organic insecticides	Active ingredient				Percentage change 1964 to 1966
	1964		1966		
	Million pounds	Percent	Million pounds	Percent	Percent
Organochlorine:					
Toxaphene	38.9	26	34.7	24	-11
DDT	33.5	23	27.0	19	-19
Aldrin	11.1	8	16.5	11	+49
TDE	3.4	2	2.9	2	-15
Other 2/	10.9	7	9.9	7	-9
Total organochlorine	97.8	66	91.0	63	-7
Organophosphorus:					
Parathion	6.4	4	8.5	6	+33
Methyl parathion	10.0	7	8.0	5	-20
Malathion	4.8	3	5.2	3	+8
Diazinon	2.3	2	5.6	4	+143
Other organophosphorus	10.4	7	12.7	9	+22
Total organophosphorus	33.9	23	40.0	27	+18
Carbamate:					
Carbaryl	14.9	10	12.4	8	-17
Other carbamate	---	---	1.0	1	---
Total carbamate	14.9	10	13.4	9	-10
Other synthetic	.8	1	.8	1	0
Total synthetics	147.4	100	145.2	100	-1

1/ Revised estimates based on (7), and data from ERS Pesticide and General Farm Survey, 1966. Crops accounted for 93 percent of the organochlorines used in 1966; livestock, 5 percent; and other uses, 2 percent.

2/ Includes BHC, chlordane, dieldrin, endosulfan, endrin, heptachlor, lindane, methoxychlor, mirex, Perthane, and Strobane.

Table 3.--Selected crops: Acres, farm value, and quantity of organochlorine insecticides used, United States, 1966

Crop	Acres 1/		Farm value 2/		Organochlorine insecticides used on crops (active ingredients) 3/	
	Million acres	Percent	Million dollars	Percent	Million pounds	Percent
Cotton	10.3	3	1,258	6	49.7	60
Corn	66.3	19	5,106	23	16.2	19
Peanuts	1.5	4/	272	1	3.3	4
Tobacco	1.0	4/	1,253	6	3.0	4
All other crops 5/	267.1	78	14,230	64	10.6	13
All crops 5/	346.2	100	22,119	100	82.8	100

1/ Calculated from acres reported in (19), and from estimates based on 1964 Census of Agriculture.
2/ Calculated from farm value reported in (22).
3/ Data from ERS Pesticide and General Farm Survey, 1966. Includes aldrin, BHC, chlordane, DDT, dieldrin, endosulfan, endrin, heptachlor, lindane, methoxychlor, mirex, Perthane, Strobane, TDE, and toxaphene.
4/ Less than 0.5 percent.
5/ Does not include pasture.

Table 4.--All crops: Quantity and percentage of organochlorine and other synthetic organic insecticides used, United States, 1966 1/

Crop	Organochlorine insecticides 2/		Other synthetic organic insecticides		Total synthetic organic insecticides	
	Million pounds	Percent	Million pounds	Percent	Million pounds	Percent
Cotton	49.7	77	15.2	23	64.9	100
Corn	16.2	69	7.4	31	23.6	100
Peanuts	3.3	59	2.3	41	5.6	100
Tobacco	3.0	79	.8	21	3.8	100
All other crops	10.6	31	23.3	69	33.9	100
All crops	82.8	63	49.0	37	131.8	100

1/ Data from ERS Pesticide and General Farm Survey, 1966.
2/ Includes aldrin, BHC, chlordane, DDT, dieldrin, endosulfan, endrin, heptachlor, lindane, methoxychlor, mirex, Perthane, Strobane, TDE, and toxaphene.

Table 5.--All crops: Quantity of organochlorine and other insecticides used, by regions, United States, 1966 1/

Synthetic organic insecticides	Pounds of active ingredients					
	Southeast	Delta States	Southern Plains	Corn Belt	Other regions	Total
	Million pounds					
Organochlorine:						
Toxaphene	13.8	7.2	5.0	0.4	4.6	31.0
DDT	10.9	7.1	2.7	.4	5.2	26.3
Aldrin	.1	---	---	13.0	1.6	14.7
TDE	.7	---	.3	.2	1.6	2.8
Other 2/	.9	2.6	.3	1.6	2.6	8.0
Total organochlorine	26.4	16.9	8.3	15.6	15.6	82.8
Organophosphorus	5.3	4.3	5.4	3.6	18.0	36.6
Carbamate	3.1	.6	2.3	1.4	5.0	12.4
Total synthetics	34.8	21.8	16.0	20.6	38.6	131.8

1/ Data from ERS Pesticide and General Farm Survey, 1966.
2/ Includes BHC, chlordane, dieldrin, endosulfan, endrin, heptachlor, lindane, methoxychlor, mirex, Perthane, and Strobane.

Table 6.--Production and farm use of methyl parathion and parathion, United States, 1963-68

Year	Methyl parathion		Parathion	
	Production	Farm use	Production	Farm use
	Million pounds			
1963	16	1/	1/	1/
1964	19	10	13	6
1965	29	1/	17	1/
1966	36	8	19	8
1967	33	1/	11	1/
1968	38	1/	2/20	1/

1/ Estimates not available.
2/ Estimated from sales data.

Source: (18) and ERS Pesticide and General Farm Surveys, 1964 and 1966.

Table 7.--Cotton: Quantity and percentage of organochlorine and other synthetic organic insecticides used, United States, 1964 and 1966 1/

Synthetic organic insecticides	Active ingredient				Percentage change 1964 to 1966
	1964		1966		
	Million pounds	Percent	Million pounds	Percent	Percent
Organochlorine:					
Toxaphene	26.9	36	27.3	42	+ 1
DDT	23.6	31	19.2	29	-19
Other 2/	5.3	7	3.2	5	-40
Total organochlorine	55.8	74	49.7	76	-11
Organophosphorus:					
Methyl parathion	8.8	12	7.2	11	-18
Parathion	1.6	2	2.2	3	+38
Malathion	1.8	2	.6	1	-67
Other 3/	3.0	4	3.6	6	+20
Total organophosphorus	15.2	20	13.6	21	-11
Carbamate:					
Carbaryl	4.5	6	1.6	3	-64
Total synthetics	75.5	100	64.9	100	-14

1/ Revised estimates based on (7), and data from ERS Pesticide and General Farm Survey, 1966.

2/ Includes aldrin, BHC, chlordane, dieldrin, endosulfan, endrin, heptachlor, lindane, methoxychlor, Strobane, and TDE.

3/ Includes Bidrin, disulfoton, trichlorfon, azinphosmethyl, ethion, naled, methyl trithion, dimethoate, demeton, phorate, Trithion, Ciodrin, and dichlorvos.

Table 8.--Cotton: Acreage, farm value, and quantity of organochlorine and other synthetic organic insecticides used, by regions, 1966

Region	Acres grown 1/		Value of sales 2/		Quantities of insecticides 3/ (active ingredients)			
					Organochlorine 4/		Other synthetics	
	Million acres	Percent	Million dollars	Percent	Million pounds	Percent	Million pounds	Percent
Southeast 5/	2.0	19	204	16	22.9	46	3.0	20
Delta States 6/	2.6	25	372	30	16.6	33	4.3	28
Southern Plains	4.7	46	386	31	7.4	15	5.2	34
Arizona and New Mexico	.4	4	100	8	2.5	5	1.9	13
California	.6	6	196	15	.3	1	.8	5
All regions	10.3	100	1,258	100	49.7	100	15.2	100

1/ Calculated from acres reported in (19).
2/ Data from (22).
3/ Data from ERS Pesticide and General Farm Survey, 1966.
4/ Includes aldrin, BHC, chlordane, DDT, dieldrin, endosulfan, endrin, lindane, methoxychlor, Strobane, TDE, and toxaphene.
5/ Includes cotton grown in Appalachian region.
6/ Includes cotton grown in Corn Belt region.

Table 9.--Cotton: Costs of substituting organophosphorus insecticides for organochlorines, by regions, United States, 1966 1/

Region	Cost of materials 2/		Additional costs		
	1966 practice	Substitute practice	Materials	Application	Total
	Million dollars				
Southeast 3/	14.7	17.3	2.5	1.9	4.4
Delta States 4/	13.3	18.1	4.9	1.9	6.8
Southern Plains	4.8	6.5	1.7	.9	2.6
Arizona and New Mexico	1.7	3.0	1.3	.2	1.5
California	.3	.4	.1	5/	.1
All regions	34.8	45.3	10.5	4.9	15.4

1/ Summary of information from regional tables 10 - 14.
2/ Costs related to organochlorine insecticides and substitute materials only.
3/ Includes cotton grown in the Appalachian region.
4/ Includes cotton grown in the Corn Belt region.
5/ Less than $50,000.

Table 10.--Cotton: Costs of substituting organophosphorus insecticides for organochlorines, Southeast region, 1966 1/

Item	Acres treated 2/	Average applications	Active ingredients: Rate per acre per application	Active ingredients: Total	Cost per pound or per application	Total cost
	1,000 acres	Number	Pounds	1,000 pounds	Dollars	1,000 dollars
1966 practices: 3/						
Toxaphene	1,181	6.1	1.9	13,713	.60	8,228
DDT	1,646	6.0	.9	8,803	.60	5,282
TDE	25	4.1	1.4	127	1.50	190
Endrin	19	6.2	.5	57	1.80	103
Strobane	39	2.8	.4	42	1.90	80
Lindane	122	2.2	.4	108	6.50	702
Other	55	1.9	.5	53	2.50	132
Total	3,087 4/(1,646)	5.8	1.3	22,903	.64	14,717
Substitute practices: 5/						
Toxaphene	1,181	1.0	1.9	2,244	.60	1,346
DDT	1,181	1.0	.9	1,063	.60	638
Methyl parathion 6/	1,181	6.0	1.0	7,086	1.20	8,503
Methyl parathion 7/	465	5.2	1.5	3,627	1.20	4,352
Bidrin 8/	465	2.0	.2	186	5.00	930
Methyl parathion 9/	260	3.2	1.5	1,248	1.20	1,498
Total	---	---	1.2	15,454	1.11	17,267
Additional costs:						
Application:						
Methyl parathion	1,181	1.0	---	---	1.00	1,181
Methyl parathion	465	.9	---	---	1.00	418
Bidrin	465	.3	---	---	1.00	140
Methyl parathion	260	.5	---	---	1.00	130
Total	---	---	---	---	---	1,869
Materials	---	---	---	---	---	2,550
Materials and applications	---	---	---	---	---	4,419

1/ Includes cotton produced in the Appalachian region.
2/ Not additive since 1 or more ingredients or different commercial preparations of a single ingredient may be applied on the same acres.
3/ Data from ERS Pesticide and General Farm Survey, 1966.
4/ Acres receiving 1 or more applications of organochlorines.
5/ To maintain production, recommended rates of organophosphorus for specifiec insect control were used and the number of applications increased 20 percent. In addition, it was assumed that 1 out of every 6 toxaphene and DDT applications used in 1966 would still be needed.
6/ For 5 toxaphene and DDT sprays primarily for boll weevils and bollworms.
7/ For 4.3 DDT sprays on acres in excess of those treated with combination toxaphene-DDT, primarily for boll weevils, bollworms, thrips, and aphids.
8/ For the remaining 1.7 DDT sprays primarily for thrips and aphids.
9/ For 2.7 organochlorine sprays other than toxaphene and DDT, primarily for bollworms, boll weevils, cabbage loopers, and aphids.

Table 11.--Cotton: Costs of substituting organophosphorus insecticides for organochlorines, Delta States region, 1966 1/

Item	Acres treated 2/	Average applications	Active ingredients: Rate per acre per application	Active ingredients: Total	Cost per pound or per application	Total cost
	1,000 acres	Number	Pounds	1,000 pounds	Dollars	1,000 dollars
1966 practices: 3/						
Toxaphene	1,173	4.3	1.4	7,152	.60	4,291
DDT	1,731	5.1	.8	7,029	.60	4,217
Strobane	186	5.6	1.9	1,961	1.90	3,726
Endrin	314	4.3	.3	420	1.80	756
Other	52	5.2	.4	108	2.50	270
Total	3,456 4/(1,731)	5.0	1.0	16,670	.80	13,260
Substitute practices: 5/						
Toxaphene	1,173	.7	1.4	1,150	.60	690
DDT	1,173	.7	.8	657	.60	394
Methyl parathion 6/	1,173	4.3	1.0	5,044	1.20	6,053
Methyl parathion 7/	558	4.1	1.5	3,432	1.20	4,118
Bidrin 8/	558	2.0	.2	224	5.00	1,120
Methyl parathion 9/	552	5.8	1.5	4,802	1.20	5,762
Total	---	---	1.1	15,309	1.18	18,137
Additional costs:						
Application:						
Methyl parathion	1,173	.7	---	---	1.00	821
Methyl parathion	558	.7	---	---	1.00	391
Bidrin	558	.3	---	---	1.00	167
Methyl parathion	552	.9	---	---	1.00	497
Total	---	---	---	---	---	1,876
Materials	---	---	---	---	---	4,877
Materials and applications	---	---	---	---	---	6,753

1/ Includes cotton produced in the Corn Belt region.
2/ Not additive since 1 or more ingredients or different commercial preparations of a single ingredient may be applied on the same acres.
3/ Data from ERS Pesticide and General Farm Survey, 1966.
4/ Acres receiving 1 or more applications of organochlorines.
5/ To maintain production, recommended rates of organophosphorus for specified insect control were used and the number of applications increased 20 percent. In addition, it was assumed that 1 out of every 6 toxaphene and DDT applications used in 1966 would still be needed.
6/ For 3.6 toxaphene and DDT sprays primarily for boll weevils and bollworms.
7/ For 3.4 DDT sprays on acres in excess of those treated with combination toxaphene-DDT, primarily for boll weevils and bollworms.
8/ For the remaining 1.7 DDT sprays primarily for thrips and aphids.
9/ For 4.9 organochlorine sprays other than toxaphene and DDT, primarily for boll weevils and bollworms.

Table 12.--Cotton: Costs of substituting organophosphorus insecticides for organochlorines, Southern Plains region, 1966

Item	Acres treated 1/	Average applications	Active ingredients: Rate per acre per application	Active ingredients: Total	Cost per pound or per application	Total cost
	1,000 acres	Number	Pounds	1,000 pounds	Dollars	1,000 dollars
1966 practices: 2/						
Toxaphene	1,280	3.5	1.1	4,895	.60	2,937
DDT	1,146	3.5	0.6	2,404	.60	1,442
Lindane	160	1.5	0.2	54	6.50	351
Endrin	71	1.7	0.3	34	1.80	61
Dieldrin	16	1.0	0.5	8	3.50	28
Total	2,673 3/(1,280)	3.5	0.8	7,395	.65	4,819
Substitute practices: 4/						
Toxaphene	1,146	.6	1.1	757	.60	454
DDT	1,146	.6	0.6	413	.60	248
Bidrin 5/	1,146	3.5	0.2	802	5.00	4,010
Methyl parathion 6/	134	4.2	1.5	844	1.20	1,013
Methyl parathion 7/	247	1.8	1.5	667	1.20	800
Total	---	---	.7	3,483	1.87	6,525
Additional costs:						
Application:						
Bidrin	1,146	.6	---	---	1.00	688
Methyl parathion	134	.7	---	---	1.00	94
Methyl parathion	247	.3	---	---	1.00	74
Total	---	---	---	---	---	856
Materials	---	---	---	---	---	1,706
Materials and applications	---	---	---	---	---	2,562

1/ Not additive since 1 or more ingredients or different commercial preparations of a single ingredient may be applied on the same acres.

2/ Data from ERS Pesticide and General Farm Survey, 1966.

3/ Acres receiving 1 or more applications of organochlorines.

4/ To maintain production, recommended rates of organophosphorus for specified insect control were used and the number of applications increased 20 percent. In addition, it was assumed that 1 out of every 6 toxaphene and DDT applications used in 1966 would still be needed.

5/ For 2.9 toxaphene and DDT sprays primarily for thrips and fleahoppers.

6/ For 3.5 toxaphene sprays on acres in excess of those treated with combination toxaphene-DDT, primarily for bollworms, boll weevils, and budworms.

7/ For 1.5 sprays other than toxaphene and DDT, primarily for bollworms, boll weevils, and armyworms.

Table 13.--Cotton: Costs of substituting organophosphorus insecticides for organochlorines, New Mexico and Arizona, 1966

Item	Acres treated 1/	Average application	Active ingredients: Rate per acre per application	Active ingredients: Total	Cost per pound or per application	Total cost
	1,000 acres	Number	Pounds	1,000 pounds	Dollars	1,000 dollars
1966 practices: 2/						
Toxaphene	183	4.4	1.7	1,374	.60	824
DDT	214	4.5	1.0	974	.60	584
Aldrin	140	1.0	.8	110	2.50	275
Dieldrin	20	1.0	.1	3	3.50	11
Total	557 3/(214)	3.4	1.3	2,461	.69	1,694
Substitute practices: 4/						
Toxaphene	183	.7	1.7	218	.60	131
DDT	183	.7	1.0	128	.60	77
Trichlorfon 5/	183	2.2	1.2	484	2.25	1,089
Azinphosmethyl 5/	183	2.2	.6	242	4.50	1,089
Methyl parathion 6/	31	5.4	1.5	250	1.20	300
Methyl parathion 7/	160	1.2	1.5	288	1.20	346
Total	---	---	1.2	1,610	1.88	3,032
Additional costs:						
Application:						
Trichlorfon	183	.4	---	---	1.00	73
Azinphosmethyl	183	.4	---	---	1.00	73
Methyl parathion	31	.9	---	---	1.00	28
Methyl parathion	160	.2	---	---	1.00	32
Total	---	---	---	---	---	206
Materials	---	---	---	---	---	1,338
Materials and applications	---	---	---	---	---	1,544

1/ Not additive since 1 or more ingredients or different commercial preparations of a single ingredient may be applied on the same acres.

2/ Data from ERS Pesticide and General Farm Survey, 1966.

3/ Acres receiving 1 or more applications of organochlorines.

4/ To maintain production, recommended rates of organophosphorus for specified insect control were used and the number of applications increased 20 percent. In addition, it was assumed that 1 out of every 6 toxaphene and DDT applications used in 1966 would still be needed.

5/ Trichlorfon and azinphosmethyl substituted equally for the 3.7 toxaphene and DDT sprays primarily for the cotton leaf perforator and the pink bollworm, respectively.

6/ For 4.5 DDT sprays on acres in excess of those treated with combination toxaphene-DDT, primarily for the cabbage looper, bollworm, and cotton leaf perforator.

7/ For 1 spray other than toxaphene and DDT, primarily for the beet armyworm, bollworm, cabbage looper, and the cotton leaf perforator.

Table 14.--Cotton: Costs of substituting organophosphorus insecticides for organochlorines, California, 1966

Item	Acres treated 1/	Average applications	Active ingredients: Rate per acre per application	Active ingredients: Total	Cost per pound or per application	Total cost
	1,000 acres	Number	Pounds	1,000 pounds	Dollars	1,000 dollars
1966 practices: 2/						
Toxaphene	64	1.0	3.4	215	.60	129
DDT	29	1.0	.5	15	.60	9
Endosulfan and lindane	66	1.0	1.1	73	1.80	131
Total	159	1.0	1.8	303	.89	269
	3/(64)					
Substitute practices: 4/						
Toxaphene	29	.2	3.4	20	.60	12
DDT	29	.2	.5	3	.60	2
Methyl parathion 5/	29	1.0	1.0	29	1.20	35
Methyl parathion 6/	35	1.2	1.5	63	1.20	76
Trichlorfon 7/	66	1.2	1.2	95	2.25	214
Total	---	---	1.5	210	1.61	339
Additional costs:						
Application:						
Methyl parathion	29	.2	---	---	1.00	6
Methyl parathion	35	.2	---	---	1.00	7
Trichlorfon	66	.2	---	---	1.00	13
Total	---	---	---	---	---	26
Materials	---	---	---	---	---	70
Materials and applications	---	---	---	---	---	96

1/ Not additive since 1 or more ingredients or different commercial preparation of a single ingredient may be applied on the same acres.
2/ Data from ERS Pesticide and General Farm Survey, 1966.
3/ Acres receiving 1 or more applications of organochlorines.
4/ To maintain production, recommended rates of organophosphorus for specified insect control were used and the number of applications increased 20 percent. In addition, it was assumed that 1 out of every 6 toxaphene and DDT applications used in 1966 would still be needed.
5/ For 0.8 toxaphene and DDT sprays, primarily for bollworms.
6/ For 1 toxaphene spray on acres in excess of those treated with combination toxaphene-DDT, primarily for cutworms, hornworms, and cabbage loopers.
7/ For 1 organochlorine spray other than toxaphene and DDT, primarily for lygus bugs.

Table 15.--Cotton: Quantity of organochlorine insecticides used in 1966, compared with substitute practices 1/

Region	Organochlorines used in 1966	Substitute practices		
		Organochlorines still needed	Organophosphorus	Total
	Million pounds			
Southeast 2/	22.9	3.3	12.2	15.5
Delta States 3/	16.7	1.8	13.5	15.3
Southern Plains	7.4	1.2	2.3	3.5
Arizona and New Mexico	2.4	.3	1.3	1.6
California	.3	4/	.2	.2
All regions	49.7	6.6	29.5	36.1

1/ Summary of information from regional tables 10-14.
2/ Includes cotton in Appalachian region.
3/ Includes cotton in Corn Belt region.
4/ Less than 50,000.

Table 16.--Corn: Acreage grown and treated with insecticides, by region, United States, 1966

Region	Planted 1/		Treated with insecticides		
			Number 2/	Percentage of acres planted	Percentage of acres treated
	Million acres	Percent	Million acres	Percent	Percent
Corn Belt	33.2	50	15.9	48	73
Lake States	9.8	15	1.9	19	9
Northern Plains	9.8	15	3.4	35	15
Other	13.5	20	0.7	5	3
All regions	66.3	100	21.9	33	100

1/ Acres planted reported in (19).
2/ Estimate of acres treated based on data from ERS Pesticide and General Farm Survey, 1966.

Table 17.--Corn: Quantity and percentage of organochlorine and other synthetic organic insecticides used, United States, 1964 and 1966 1/

Synthetic organic insecticides	Active ingredient				Percentage change 1964 to 1966
	1964		1966		
	Million pounds	Percent	Million pounds	Percent	Percent
Organochlorine:					
Aldrin	10.7	68	14.2	60	+ 33
Heptachlor	1.1	7	1.5	6	+ 36
Other 2/	0.4	3	0.5	3	+ 25
Total organochlorine	12.2	78	16.2	69	+ 33
Organophosphorus:					
Diazinon	1.5	9	4.0	17	+167
Parathion	0.7	4	1.9	8	+171
Other 3/	1.2	8	0.8	3	- 33
Total organophoshhorus	3.4	21	6.7	28	+ 97
Total carbamate	0.1	1	0.7	3	4/
Total synthetics	15.7	100	23.6	100	+ 50

1/ Revised estimates based on (7), and data from ERS Pesticide and General Farm Survey, 1966.

2/ Includes lindane, TDE, DDT, dieldrin, chlordane, benzene hexachloride, and toxaphene.

3/ Includes disulfoton, methyl parathion, malathion, phorate, and ethion.

4/ Quantities too small to compute a meaningful estimate of change.

Table 18.--Corn: Quantity of selected insecticides used on corn, selected States, 1966 1/

State	Aldrin	Hepta-chlor	Dia-zinon	Para-thion	Carbaryl
	Million pounds				
Ohio	0.6	0.1	---	---	---
Indiana	1.4	0.3	---	---	---
Illinois	6.0	0.5	0.1	---	---
Minnesota	0.6	---	0.5	0.1	---
Iowa	3.4	0.4	1.4	0.6	---
Missouri	1.3	0.2	0.3	---	0.1
Nebraska	0.1	---	1.2	0.6	0.2
Total	13.4	1.5	3.5	1.3	0.3

1/ Data from ERS Pesticide and General Farm Survey, 1966.
--- Indicates that there was no use of the product or less than 50,000 pounds were used.

Table 19.--Corn: Acreage treated for wireworms and white grubs and quantities of aldrin and heptachlor used, major corn-producing States, 1966

State	Acres planted	Treatment for wireworms and white grubs				
		Percentage of planted acreage 1/	Acreage treated 2/		Pounds of insecticides used 2/	
			Aldrin	Heptachlor	Aldrin	Heptachlor
	1,000 acres	Percent	1,000 acres	1,000 acres	1,000 pounds	1,000 pounds
Ohio	3,338	10	291	43	308	32
Indiana	5,256	10	457	69	484	50
Illinois	10,684	40	3,712	562	3,935	410
Iowa	10,676	32	2,967	449	3,145	328
Missouri	3,108	40	1,080	163	1,146	119
Nebraska	4,415	3	115	17	122	12
Other States	28,829	2	608	92	644	67
All States	66,306	16	9,230	1,395	9,784	1,018

1/ Based on acres treated and quantities of aldrin and heptachlor used by States from ERS Pesticide and General Farm Survey, 1966, table 18, and estimates by State extension entomologists of acreages treated for soil insects.

2/ Based on 1966 experience, 87 percent of the treated acreage received aldrin at 1.06 pounds per acre, and 13 percent received heptachlor at 0.73 pounds per acre.

Table 20.--Corn: Cost of substituting organophosphorus and carbamate insecticides for organochlorines, United States, 1966

Insecticide materials	Acres treated	Active ingredient		Cost per pound	Total cost
		Rate per acre	Total		
	1,000 acres	Pounds	1,000 pounds	Dollars	1,000 dollars
Soil insect control:					
1966 practices: 1/					
Aldrin	13,386	1.06	14,244	1.50	21,366
Heptachlor	2,026	0.73	1,484	1.50	2,226
Lindane	349	0.13	44	6.00	264
Total	15,761		15,772		23,856
Substitute practices: 2/					
Aldrin	9,230	1.06	9,784	1.50	14,676
Heptachlor	1,395	0.73	1,018	1.50	1,527
Diazinon	5,136	1.00	5,136	2.70	13,867
Total	15,761		15,938		30,070
Additional cost of substitute practices					6,214
Corn borer and surface insect control: 3/					
1966 practices: 1/					
DDT	351	0.67	234	0.80	187
Chlordane	210	0.76	160	1.00	160
Toxaphene	20	0.20	4	0.60	2
Dieldrin	183	0.28	51	3.50	178
TDE and other	18	0.28	5	1.50	8
Total	782		454		535
Substitute practices:					
Carbaryl	782	1.57	1,228	1.30	1,596
Additional cost of substitute practices					1,061
All corn insect control:					
1966 practices 1/	16,543 4/(15,761)		16,226		24,391
Substitute practices	16,543 4/(10,625)		17,166		31,666
Additional cost of substitute practices					7,275

1/ Based on data from ERS Pesticide and General Farm Survey, 1966.
2/ See table 19 for acreage treated and quantities of aldrin and heptachlor used by States.
3/ Foliar spray treatment for corn borers; aboveground basal spray treatment for cutworms.
4/ Total acres receiving 1 or more applications of organochlorines.

Table 21.--Peanuts: Acreage treated and quantity of organochlorine and other synthetic organic insecticides used, United States, 1966 1/

Synthetic organic insecticides	Use of insecticides, 1966	
	Acres treated	Active ingredients
	1,000 acres	1,000 pounds
Organochlorine:		
DDT	500	2,265
Toxaphene	237	985
Lindane	21	19
All organochlorine	---	3,269
Other synthetic:		
Carbamate (carbaryl)	371	1,885
Organophosphorus 2/	283	374
All other	---	2,259
Total synthetics	3/1,412 4/(1,043)	5,528

1/ Data from ERS Pesticide and General Farm Survey, 1966.
2/ Includes disulfoton, diazinon, malathion, methyl parathion, parathion, and phorate.
3/ Not additive since 1 or more ingredients or different commercial preparations of a single ingredient may be applied on the same acres.
4/ Total acres receiving 1 or more applications of insecticides.

Table 22.--Peanuts: Acreage, farm value, and quantity of organochlorine and other synthetic organic insecticides used, selected regions, 1966

Region	Acres 1/		Value sales 2/		Organochlorines used on peanuts (active ingredients) 3/		Other synthetics 3/	
	1,000 acres	Percent	Million dollars	Percent	1,000 pounds	Percent	1,000 pounds	Percent
Appalachian	276	18	75	28	142	4	904	40
Southeast	783	53	127	47	3,127	96	1,355	60
Other	431	29	70	25	---	---	4/	4/
All regions	1,490	100	272	100	3,269	100	2,259	100

1/ Calculated from acres reported in (19).
2/ Data from (22).
3/ Data from ERS Pesticide and General Farm Survey, 1966.
4/ A small quantity of insecticides used in the Texas-Oklahoma production area.

Table 23.--Peanuts: Costs of substituting organophosphorus and carbamate insecticides for organochlorines, United States, 1966

Item	Acres treated	Average applications	Active ingredients: Rate per acre per application	Active ingredients: Total	Cost per pound or per application	Total costs
	1,000 acres	Number	Pounds	1,000 pounds	Dollars	1,000 dollars
1966 practices: 1/						
DDT	500	2.4	1.9	2,265	1.00	2,265
Toxaphene	237	1.6	2.6	985	1.00	985
Lindane	21	3.0	.3	19	6.50	124
Total	2/758 3/(500)	2.2	2.0	3,269	1.03	3,374
Applications	4/521	2.4	---	---	5/1.15	1,438
Total materials and applications						4,812
Substitute practices: 6/						
Carbaryl	500	1/2.7	1/.9	1,215	1.70	2,065
Diazinon	258	1.6	2.0	826	2.70	2,230
Total	758	2.3	1.2	2,041	2.10	4,295
Applications:						
Carbaryl	500	2.7	---	---	5/1.15	1,553
Diazinon	258	1.6	---	---	5/1.00	413
Total	758	2.3	---	---	---	1,966
Total materials and applications	---	---	---	---	---	6,261
Additional costs	---	---	---	---	---	1,449

1/ Data from ERS Pesticide and General Farm Survey, 1966.
2/ Not additive since 1 or more ingredients or different commercial preparations of a single ingredient may be applied on the same acres.
3/ Total acres receiving 1 or more applications of organochlorines in 1966.
4/ Acres treated with DDT and lindane used in calculating application costs. Toxaphene usually applied at the same time as the DDT.
5/ Application costs based on (4).
6/ Carbaryl substituted for DDT to control leafhoppers and thrips. Diazinon substituted for toxaphene and lindane to control cutworms. Since diazinon is usually applied in granular form, application costs are lower than for carbaryl.

Table 24.--Tobacco: Acreage, farm value, and quantity of organochlorine insecticides used, selected States, 1966

State	Acres harvested 1/		Value of sales 1/			Organochlorine used on tobacco 2/ (active ingredients)	
			Total		Per acre harvested		
	1,000 acres	Percent	Million dollars	Percent	Dollars	1,000 pounds	Percent
North Carolina	415	43	519	41	1,249	1,154	38
Kentucky	177	18	284	23	1,606	148	4
Other States	382	39	450	36	1,178	1,756	58
Total	974	100	1,253	100	1,286	3,058	100

1/ Data from (22).

2/ Data from ERS Pesticide and General Farm Survey, 1966. Includes aldrin, chlordane, DDT, dieldrin, endosulfan, endrin, heptachlor, lindane, methoxychlor, Perthane, Strobane, TDE, and toxaphene.

Table 25.--Tobacco: Quantity and percentage of organochlorine and other synthetic organic insecticides used, United States, 1964 and 1966 1/

Synthetic organic insecticides	Pounds of active ingredients							
	1964		1966					
			Total		Growing crop		Plant beds and transplants	
	1,000 pounds	Percent	1,000 pounds	Percent	1,000 pounds	Percent	1,000 pounds	Percent
Organochlorine:								
TDE	2,331	44	1,767	45	1,764	48	3	1
DDT	1,187	22	925	24	781	21	144	73
Toxaphene	292	5	150	4	150	4	2/	2/
Aldrin	135	3	85	2	80	2	5	3
Endrin	150	3	22	1	20	1	2	1
Dieldrin	93	2	22	1	20	1	2	1
Other 3/	149	2	87	2	70	2	17	9
Total organochlorine	4,337	81	3,058	79	2,885	79	173	88
Organophosphorus:								
Parathion	466	9	421	11	409	11	12	6
Malathion	101	2	24	1	23	1	1	1
Diazinon	74	1	123	3	116	3	7	3
Other	45	1	34	1	34	1	---	---
Total organophosphorus	686	13	602	16	582	16	20	10
Carbamate 4/	335	6	209	5	206	5	3	2
Total synthetics	5,358	100	3,869	100	3,673	100	196	100

1/ Revised estimates based on (7), and data from ERS Pesticide and General Farm Survey, 1966.
2/ Less than 500 pounds.
3/ Includes chlordane, endosulfan, heptachlor, lindane, methoxychlor, Perthane, and Strobane.
4/ Only carbaryl used in 1966. A small amount of other carbamates used in 1964.

Table 26.--Tobacco: Costs of organochlorine insecticides used, United States, 1966

Insecticide material and use	Acres treated	Average applications	Active ingredients: Rate per acre per application	Active ingredients: Total	Cost per pound	Total costs
	1,000 acres	Number	Pounds	1,000 pounds	Dollars	1,000 Dollars
1966 practices: 1/						
Used on tobacco fields:						
TDE	623	2.5	1.1	1,764	1.50	2,646
DDT	395	2.5	.8	781	1.00	781
Toxaphene	61	1.6	1.5	150	1.00	150
Aldrin	51	1.8	.9	80	2.50	200
Endrin	24	2.0	.4	20	1.80	36
Dieldrin	80	2.0	.1	20	3.50	70
Other 2/	58	1.2	.9	70	2.00	140
Total	3/1,292 4/(623)	2.4	.9	2,885	1.39	4,023
Used on plantbeds and transplants 5/	---	---	---	173	1.00	173
Total, all uses	---	---	---	3,058	1.37	4,196

1/ Data from ERS Pesticide and General Farm Survey, 1966.
2/ Includes chlordane, endosulfan, heptachlor, lindane, methoxychlor, Perthane, and Strobane.
3/ Not additive since 1 or more ingredients or different commerical preparations of a single ingredient may be applied on the same acres.
4/ Total acres receiving 1 or more applications of organochlorine insecticides in 1966.
5/ Largely DDT.

Table 27.--Tobacco: Costs of substituting organophosphorus and carbamate insecticides to control insects on acreages treated with organochlorines, United States, 1966

Item	Acres treated	Average applications 1/	Active ingredients: Rate per acre per application	Active ingredients: Total	Cost per pound or application	Total costs
	1,000 acres	Number	Pounds	1,000 pounds	Dollars	1,000 dollars
Substitute practice: 2/						
Used on tobacco fields: 3/						
Carbaryl:						
Replacing TDE	623	3.0	1.1	2,056	1.20	2,467
Replacing DDT	395	3.0	1.1	1,304	1.20	1,565
Parathion	178	2.5	.6	267	1.50	401
Diazinon	96	2.5	.8	192	2.50	480
Total	4/1,292 5/(623)	2.9	1.0	3,819	1.29	4,913
Used on plantbeds and transplants 6/	---	---	---	247	1.20	296
Total all uses	---	---	---	4,066	1.28	5,209
Additional costs:						
Materials	---	---	---	---	---	1,013
Applications	1,292	0.5	---	---	2.50	1,615
Total	---	---	---	---	---	2,628

1/ Number of applications increased by 20 percent over treatments using organochlorine insecticides to gain effective control.

2/ Rates and prices from ERS Pesticide and General Farm Survey, 1966.

3/ Carbaryl used to control hornworms and budworms. Parathion and diazinon replaced toxaphene, aldrin, endrin, dieldrin, and other organochlorines. No single insecticide used exclusively to control a given insect. Either parathion or diazinon used to control wireworms, aphids, plus other foliage feeding insects. Acres treated with parathion or diazinon allocated in the same proportion as acres treated by users in 1966.

4/ Not additive since 1 or more ingredients or different commercial preparations of a single ingredient may be applied on the same acres.

5/ Total acres receiving 1 or more applications of organochlorine insecticides in 1966.

6/ 50 percent more carbaryl than DDT. It was assumed that carbaryl could be substituted for DDT for controlling cutworms. Currently, carbaryl is not registered for use on tobacco for cutworm control, but it is registered for controlling similar species of curworms on cotton.

Table 28.--Quantity of insecticides used on cotton, corn, peanuts, and tobacco, compared with estimated use if organochlorines were restricted, United States, 1966

Insecticide	Cotton		Corn		Peanuts		Tobacco		Total	
	1966 uses 1/	Substitute practice	1966 uses 1/	Substitute practice	1966 uses 1/	Substitute practice	1966 uses 1/	Substitute practice	1966 uses 1/	Substitute practice
	Million pounds									
Organochlorine:										
Toxaphene	27.3	4.4	---	---	1.0	---	0.1	---	28.4	4.4
DDT	19.2	2.2	.2	---	2.3	---	0.9	---	22.6	2.2
Aldrin	0.1	---	14.2	9.8	---	---	0.1	---	14.4	9.8
Heptachlor	---	---	1.5	1.0	---	---	---	---	1.5	1.0
Other 2/	3.1	---	.3	---	---	---	2.0	---	5.4	---
Total organochlorine	49.7	6.6	16.2	10.8	3.3	---	3.1	---	72.3	17.4
Organophosphorus:										
Parathion	2.2	2.2	1.9	1.9	---	---	0.4	0.7	4.5	4.8
Methyl parathion	7.2	34.6	---	---	---	---	---	---	7.2	34.6
Malathion	.6	.6	---	---	---	---	---	---	.6	.6
Diazinon	---	---	4.0	9.1	0.1	0.9	0.1	0.3	4.2	10.3
Bidrin	1.9	3.1	---	---	---	---	---	---	1.9	3.1
Other	1.7	2.5	0.8	0.8	0.3	0.3	0.1	0.1	2.9	3.7
Total organophosphorus	13.6	43.0	6.7	11.8	0.4	1.2	0.6	1.1	21.3	57.1
Carbamate:										
Carbaryl	1.6	1.6	0.7	1.9	1.9	3.1	0.2	3.8	4.4	10.4
Total synthetics	64.9	51.2	23.6	24.5	5.6	4.3	3.9	4.9	98.0	84.9

1/ Based on ERS Pesticide and General Farm Survey, 1966.
2/ Includes TDE, endrin, chlordane, Strobane, mirex, Perthane, lindane, BHC, methoxychlor, and dieldrin.

Table 29.--Costs of substituting organophosphorus and carbamate insecticides for cotton, corn, peanuts, and tobacco, United States, 1966

Item	Unit	Cotton	Corn	Peanuts	Tobacco	Total
1966 practices 1/	Mil. dol.	34.8	24.3	4.8	4.2	68.2
Substitute practices:						
Organochlorines	do.	4.0	16.2	---	---	20.2
Organophosphorus	do.	46.1	13.9	2.7	1.2	63.9
Carbamate	do.	---	1.6	3.6	5.6	10.8
Total	do.	50.1	31.7	6.3	6.8	94.9
Additional costs:						
Materials	do.	10.6	7.3	.9	1.0	19.8
Application	do.	4.8	---	.5	1.6	6.9
Total	do.	15.4	7.3	1.4	2.6	26.7
Per acre treated with organochlorines	Dollars	3.12	1.23	2.90	4.22	2.23
Proportion of crop value	Percent	1.2	.2	.5	.2	.3

1/ Data from ERS Pesticide and General Farm Survey, 1966.

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CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife -- if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.